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Forest Service

Forestry Research West

April 1990

A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

In This Issue

Cover

Scientists with the Pacific Southwest Station have been analyzing chemical impurities that collect in rime ice in the Sierra Nevadas, and working to determine their effects on forest ecosystems. For details, turn to page 4 .

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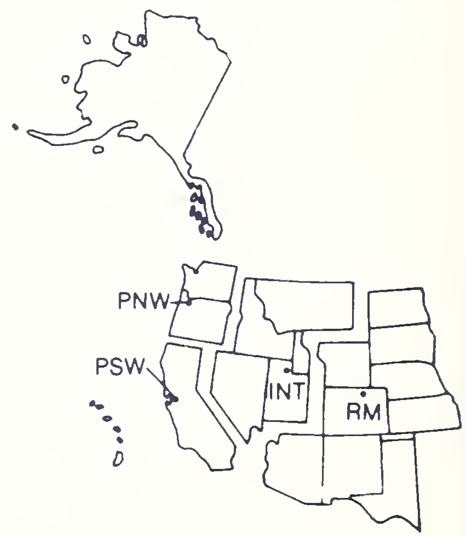


Wildlife habitat on the rocks

by Rick Fletcher
Rocky Mountain Station

It's early June, 1985, night has fallen in the Powder River Basin of Wyoming and Montana, and Wildlife Biologist Mark Rumble is busy setting traps. He's censusing small mammal species richness and abundance in this region. In addition, he's spending mornings counting and recording bird sightings. He was spearheading a unique study to evaluate which habitat characteristics to include in mine spoil reclamation plans for sustaining or increasing post-mining wildlife productivity. "Historically, wildlife habitat has been on the decline due to activities such as road building, river channelization, and community expansion," says Rumble, a scientist with the Rocky Mountain Station's Forestry Sciences Laboratory in Rapid City, South Dakota. "Those responsible for reclaiming mine spoils have a tremendous opportunity to recreate or improve wildlife habitat."

Rumble's emphasis was on rock outcrops. He believes they play an integral part in reclamation efforts—increasing the number of wildlife species inhabiting an area by providing structural diversity to the sagebrush/grasslands typical of the coal mine region of the northern Great Plains. "Even though these studies were done in the Powder River Basin, results should be applicable to reclamation efforts throughout most of the western U.S.," he said.

An example of natural scoria outcrops – so essential to some wildlife species.

Study methods

Rumble's research Involved 38 sites, selected in a paired design: half in scoria (slag from burned-out coal seams) outcrop habitats, and half in the surrounding sagebrush/grassland. Outcrop study sites were selected to represent the full range of available outcrop habitats in the area, from high to low densities of outcrops, and small to large outcrops. Sagebrush/grassland sites were selected in vegetation similar to the outcrop habitats.

Birds were counted on the study sites during the breeding season using variable circular plots. After a short initial waiting period, all birds seen or heard were recorded during a 6-minute census on each plot.

Small mammals were sampled on 14 of the study sites: 7 in outcrop habitats, and 7 in sagebrush/grassland habitats. On each of these sites a grid of live traps, spaced at 10-meter intervals, was established. The grid was centered over the sample point used for bird counts.

Bird results

"Twenty-four bird species were recorded within 50 meters of the census points," said Rumble. He found that several species of birds occurred only in the outcrop habitats, and estimates of total bird abundance were nearly 5 times greater in the shrub communities associated with outcrops than in the surrounding sagebrush/grasslands. Lark sparrows were the most abundant species; their density in the rock outcrops was nearly 20 times greater than in the sagebrush/grasslands. Rock wrens, rufous-sided towhees, and American robins occurred only in outcrop habitats. Rock outcrop habitats supported an average of 4.5 species per site, as compared with 3.1 species per site in the surrounding sagebrush/grasslands.

Mammal results

Two species of lagomorphs (hares and rabbits) and six species of small rodents were recorded on the study sites. "We found that cottontails and deer mice were more abundant in the outcrop habitats,"

Lark sparrows are more abundant around outcrops because of the shrub communities that are adjacent to the rocks.

says Rumble, "and would benefit from the establishment of rock outcrops during reclamation. Cottontails prefer rocky and/or brush habitats for cover. The rocks and shrubs associated with the outcrops provide cover that is not available in sagebrush/grassland sites. Although deer mice are associated with the more open habitats, as opposed to habitats with high herbaceous cover," he said, "the cracks and crevices at the base of, and between rocks, provide good nest sites."

Rumble is the first to admit that his studies show not all birds or small mammals are dependent on rock outcrops—vesper sparrows, lark buntings, northern orioles, brown-headed cowbirds, thirteen-lined ground squirrels, pocket mice, and prairie voles showed either an indifference to outcrops or a preference for sagebrush/grasslands. "But let's look at the bottom line," he says. "These studies show, without a doubt, that rock outcrops can create diverse habitat beneficial for wildlife enhancement. Most species of birds or mammals that occurred in outcrop habitats also occurred in the sagebrush/grasslands, but at lower abundance," says Rumble.

His data suggest, that in order to maximize the restoration of wildlife habitat, both sagebrush/grassland and outcrop habitats should be considered essential to any reclamation effort. Correlations with habitat variables suggest that many of the species more abundant in and around outcrops were selecting these sites due to better availability of nesting, resting/perching, and feeding sites.

On reclaimed lands, establishment of shrubs can be expensive and, in the case of sagebrush, difficult. However, rock and rock outcrops can facilitate the establishment of many relatively mesic (adapted to an environment having a balanced supply of moisture) shrub species by providing seedlings shade, water runoff, and protection from wind.

More information available

If you'd like more information on incorporating rock outcrops into reclamation plans, contact Mark Rumble (who also has suggestions on structuring outcrops) at the Forestry Sciences Laboratory, South Dakota School of Mines and Technology, 501 East St. Joe, Rapid City, South Dakota 57701, phone (605) 394-1960, FTS – 8-605-394-1960.

This research is also detailed in *Wildlife Associated with Scoria Outcrops: Implications for Reclamation of Surface-mined Lands*, Research Paper RM-285, available from the Rocky Mountain Station.

These rock outcrops have been placed on reclaimed spoils. Despite the effort, Rumble points out that they are too scattered and too few to be very effective.

Cattle have trampled any hope of shrub establishment near this outcrop. Without the shrubs, benefits to wildlife are greatly reduced.

Analyzing the chemistry of snow and ice

by J. Louise Mastrantonio
for Pacific Southwest
Station

Rime ice-encrusted conifers at the crest of the Sierra Nevada.

It may still be beautiful, but the powdery white stuff that falls in the mountains in winter—even the ice or "rime" that collects on trees—is no longer pure.

That conclusion comes from research over the past twenty years—from studies in Canada, the eastern United States, Europe, and most recently from California where U. S. Forest Service scientists have been analyzing the chemical composition of ice and snow in the Sierra Nevada.

The California research, conducted by the Pacific Southwest Station under the direction of Project Leader Neil Berg, has been going on since the early 1980's. About that time, scientists began to suspect a link between air pollution and forest decline in the eastern United States and Europe. In some places, a surge of acidity occurred in streams during spring snowmelt, killing fish and lowering reproduction rates in amphibians.

"We wanted to know if the same thing was happening in California," Berg says. At the time, the Forest Service hydrologist had been doing research on snow physics—learning how water moves through snow and its effect on snow runoff and flooding. Looking at the chemistry of snow and snowmelt was a logical next step.

But there was very little to go on. Precipitation data had been collected at the agency's Central Sierra Snow Laboratory near Donner Pass in the Sierra Nevada since 1899 and there was considerable data on snow hydrology but almost nothing on snow chemistry. After nearly ten years of research, however, scientists now have a much better understanding of the contribution of snow and ice to pollution in mountain streams. And they have developed baseline data that can be used to determine changes in snow chemistry should they occur in the future.

Impurities found

Fortunately, the news from this research is relatively good. "Winter precipitation in the Sierra Nevada is probably in pretty good shape compared to most places in the world," Berg reports. It is not completely pristine, however. Impurities were often found in higher amounts than would normally be expected, especially in snowmelt and ice. These impurities include hydrogen, nitrate and sulfate (the major precursors of acid rain), and lesser amounts of calcium, chloride, sodium, potassium, and magnesium.

The research also suggests that the pollutants tend to be discharged to the soil and streams in concentrated amounts or "pulses." This means that, although the total amount of nitrate, sulfate or hydrogen in the snowpack might not be high, its discharge into streams at particular times may be cause for concern, especially if pollution increases in the future.

Initial study inconclusive

In Berg's first study, he collected and analyzed snow and snowmelt from a one-half acre forest clearing at the Central Sierra Snow Laboratory. Precipitation rates there are high, with a total of 400 inches of snowfall a year. Storms generally move in from the West or Southwest bringing pollution from the San Francisco and Sacramento metropolitan areas and from agricultural areas of the Central Valley.

Snow samples were taken during the winter of 1983–84 and analyzed for pH (an index of hydrogen ion activity and a measure of acidity), nitrate, and sulfate. A similar analysis of pH was also done in 1985 but nitrate and sulfate measurements could not be taken because of the expense involved. Measurement of pH is relatively easy and can be done inexpensively and accurately in a field laboratory. Nitrate and sulfate analysis is more expensive, must be done in a well equipped laboratory, and samples can easily be contaminated. "A fingerprint in a sample container is enough to bias the results," Berg says.

During the two spring melt periods in 1983–84, Berg found no evidence of increased acidity in snowmelt. During February 1985, however, a strong alkaline "pulse" was detected, an anomaly he suggests may have been caused by east winds blowing alkaline dust in from the east side of the mountains.

This initial study served mainly to focus the later work. In effect, it raised more questions than it answered. For example, what happened to the expected increase in acidity? Berg thought it might already have washed out of the snowpack by the time data collection began on January 1, an idea supported by the fact that peak acidity of stream water occurred in mid December. Or maybe the level of acidity was not strong enough to show up with the relatively limited amount of sampling that had been done.

Impurities found in snowmelt

In a subsequent study, Berg took more samples and extended the sampling period to include early winter months. This time a high proportion of impurities (notably chloride, nitrate, sulfate, and hydrogen) was detected coming out at the early stage of each melt period.

Berg wasn't completely surprised. After all, the eastern research had shown a pulse of acidity coming out of the snowpack in the spring. Now the California data was showing a series of small pulses related to rain-on-snow events regardless of when they occurred. The key then was melt. Whenever the snow began to melt there was an initial surge of acidity that subsided as melt continued.

Researchers needed an explanation. If the impurities were distributed evenly in the snowpack as they were laid down, why weren't they released in a similar manner? The answer is something scientists call "fractionation." This means that the chemical impurities are deposited in the snowpack so they move out when the snow begins to melt. As melt continues, there is less and less of the chemical available to wash out.

One theory is that the foreign chemicals do not reside squarely within the snow crystal. Snow is basically frozen water, hydrogen and oxygen molecules in their purest form, and the snow crystals, as they are forming, tend to exclude foreign matter. "The pollutants remain on the outer shell of the grain of snow," Berg indicates. When the snow crystals begin to melt, the pollutants are simply "lined up" in such a way that they leave first.

Pollutants found in rime

About the time Berg was beginning to get data from the snow studies, he also began looking at rime—the ice that forms when cold water drops in the atmosphere freeze onto a solid surface. Unlike moss on trees, rime accumulates toward the prevailing wind and is, in fact, a good indicator of wind direction. Riming occurs only at sites exposed to the wind and, locally in the Sierra Nevada, it may contribute significant amounts of precipitation—water added to high elevation watersheds without ever falling as rain or snow.

Rime can occur in several forms—as dense masses, in feathery patterns, or as needle-like spires. As beautiful and interesting as it may be, however, there are two major reasons for studying rime: 1) icing causes considerable damage to power and communication lines and towers all across the country, and 2) trees and other vegetation may be damaged by pollutants in the ice.

In a recent issue of *Arctic and Alpine Research* (Vol. 20, No. 4, 1988), Berg reports results of several years of research on the chemistry of rime deposits. Data was gathered during the winter of 1986–87 at six sites in the central Sierra Nevada and for three consecutive winters at another location in northern California. In these places, riming turned out to be a common occurrence, occurring on an average of 38 percent of winter days.

Data collection

Multiple weather readings were taken including data on wind speed and direction, air temperature, relative humidity and icing. Some of the data was gathered by hand and supplemented with visual and photographic observations. Other data was obtained from automated data-sensing platforms. Some was also collected as part of the U.S. Bureau of Reclamation's Sierra Cooperative Pilot Project from PROBE Stations (Portable Remote Observation of the Environment), telemetered to the Bureau's office in Denver, Colorado, and then sent to the Experiment Station office in Berkeley on magnetic tape.

Collectors for monitoring the chemistry of rime ice.

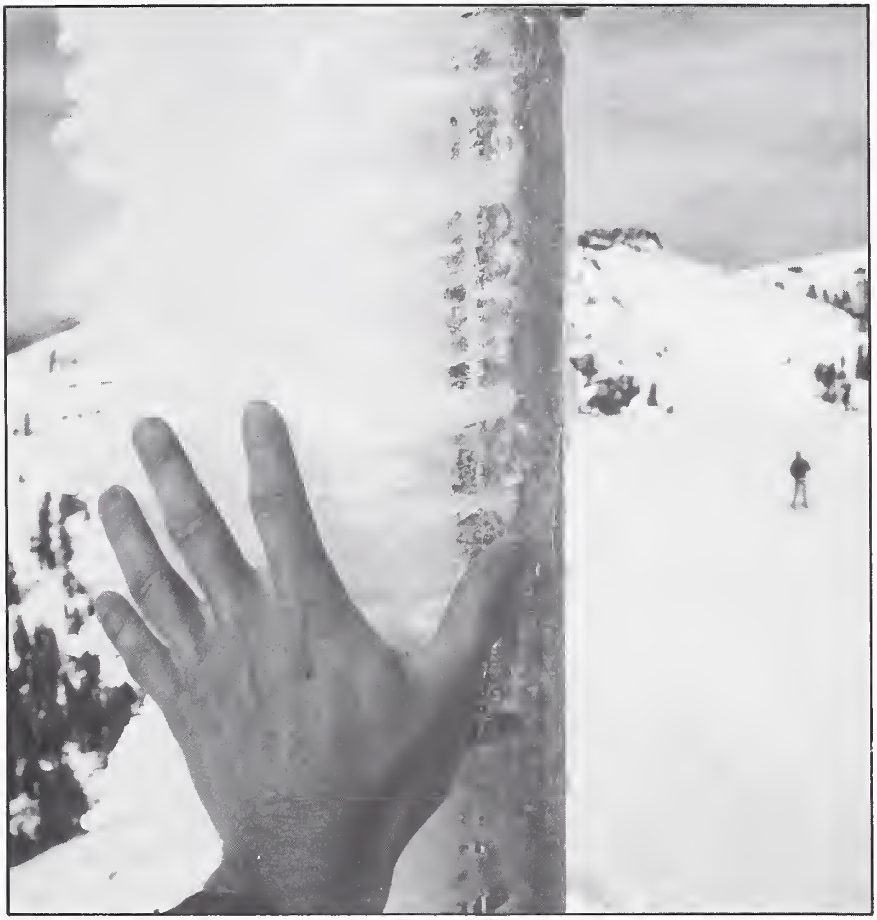
Such extensive data collection eventually enabled scientists to develop a mathematical model to estimate the occurrence of rime. "We didn't start out to do that," Berg says. "It just happened. I thought if riming made an important contribution to pollution, we would want to know when it was occurring." From known weather data, riming events were correctly classified by the model more than 82 percent of the time. The absence of riming was correctly classified in more than 92 percent of the cases.

Ice incorporates chemical impurities

As part of this same study, Berg collected samples of rime for chemical analysis at the northern California site and at three Sierra Nevada locations. This time, he found concentrations of nitrate, sulfate, chloride, calcium, potassium, sodium, magnesium, and hydrogen that were typically from 1.8 to 6 times that of snow. The pH of snow ranged from 5 to more than 5.6 (within the range of natural occurrence) while the pH of rime ranged from 4.3 to 5.5. This means that ice is more acid than snow. The reason, according to Berg, is physics. The ice molecule tends to incorporate chemical impurities while they are "tacked onto" the snow crystal in a more fragile way.

Manmade sources

The principal pollutants in both snow and ice are nitrate, sulfate, and hydrogen. "The nitrate and sulfate," Berg says, "come from manmade sources. . .auto exhaust, industry, agricultural operations." They are precursors to nitric and sulfuric acid and are the major components of "acid" rain. Sulfuric acid, for example, is H_2SO_4 and nitric acid is HNO_3. It is hydrogen that is an index of acidity: the more hydrogen, the lower the pH and the more acidic the compound.



Rime ice.

What is most important out of all this work, Berg believes, is the knowledge that snow and ice is a repository for pollutants in the environment and that they tend to leach out of the snow in uneven pulses. In effect, pollutants are trapped in ice and snow, put in "cold storage," and dumped into streams in winter and spring—at a time when they could adversely affect development of young fish and aquatic organisms.

Research moves in new direction

Whether they do or not is another matter. Berg believes the magnitude of chemical change in the snowpack in California is not enough now to adversely affect biological function. But there are other environmental impacts to consider. He and his staff (Lynn Decker, a fish biologist; Bruce McGurk, hydrologist; and Dave Azuma, statistician), have pretty much completed the snow physics and snow chemistry work. Now they will be moving in a new direction.

"In the past, most people have been concerned about the environmental impacts of individual activities," Berg says. "But we can't just look at one part of the environment. The National Environmental Policy Act of 1969 requires managers to consider the cumulative effects of <u>all</u> current foreseeable management activities. We have to look at the possible harmful effects that several activities, such as successive timber harvests, mining, or recreation impacts, might have in the same watershed."

"We've been grappling with this for several months now," Berg says. He sees it as a problem of sorting out the various environmental influences to get at the cumulative effects. That won't be easy, but no analysis of environmental impacts will be accurate until better ways are found to measure the additive effects of these different activities.

For more information on this subject, please contact the Pacific Southwest Research Station to request the following reprints of articles by Dr. Berg: *Mountain-top Riming at Sites in California and Nevada; Snow Chemistry in the Central Sierra Nevada, California;* and *Chemistry of Rime Ice at Four Sites in California.*

The challenge of restoring native ranges

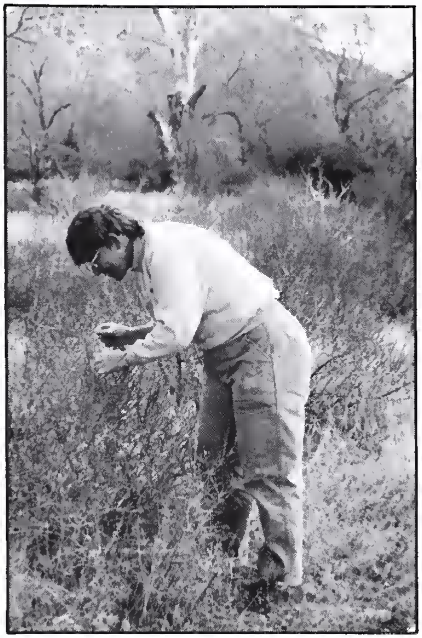
by Frances Reynolds
Intermountain Station

. . . between 1880 and 1905, the Wasatch Range, from Thistle to Salina, was a vast dust bed, grazed, trampled and burned to the utmost. The timber cover was reduced, the brush thinned, the weeds and grass cropped to the roots, and such as existed was broken and worn.

These conditions, recorded by Forest Examiner Robert V. Reynolds in 1911, existed not only in Sanpete County, Utah, but in much of the West at the turn of the century. Prolonged abuse of the land had resulted in the loss of valuable forage species and topsoil.

The following year, Forester Henry S. Graves responded to the urgent needs of farmers and ranchers by establishing the Great Basin Experiment Station on the Wasatch Plateau in Sanpete County. One of the predecessors of today's Intermountain Research Station, the Great Basin Station became the headquarters for research on ecology and management of watershed and rangelands.

Research continues today at a more modern facility: the Intermountain Station's Shrub Sciences Laboratory in Provo, Utah, now an internationally recognized center for the study of shrubs and other western range plants. Past research accomplishments, such as development of techniques to restore big-game winter range and improve range productivity, are being built upon with new studies to develop and manage improved shrubs and other plants.



Dr. Susan Meyer examines adaptation of a strain of antelope bitterbrush near Provo, Utah. Scientists at the Shrub Sciences Laboratory are working to develop improved shrubs for restoring range and wildlife habitat.

Going Native

Over the years, laboratory scientists have worked to increase awareness of the value of using native vegetation in restoration of range and wildlife habitats. Native plant communities—comprising a mix of shrubs, broadleaf plants, and grasses—provide a diversity of forage for wildlife, as well as hiding and thermal cover. Even species that are generally not regarded as palatable for wildlife may have significant forage value for brief periods when other forage is unavailable.

The concept of restoring the diversity of whole plant communities is gaining acceptance. "In fact," points out Dr. Susan Meyer, an Ecologist, "some states, like Montana, require that mined areas be revegetated with native plants only. This is a requirement for many specially designated areas too, like wildernesses and research natural areas." The concept isn't always easy to put into practice, though.

"A lot can go wrong when you're seeding native plants," Meyer explains. "The seeds are generally collected by hand from wild plants, so quality is inconsistent even though the cost is relatively high. Seeds may or may not germinate, may or may not become established."

It's hardly surprising, then, that revegetation has generally been carried out with seed mixes having a high proportion of introduced species, such as crested wheatgrass and alfalfa. In addition to providing forage, these species have practical advantages: seed is relatively inexpensive; seed quality is consistent; and germination and establishment characteristics are predictable. Introduced species will usually succeed in artificial seedings, but native seeds may not even germinate. That's where Meyer's research will help.

Patterns of success and failure

Meyer has documented differences in germination patterns within some western shrub species that may account for the success of some seedings and the failure of others under similar circumstances. By understanding these infraspecific variations, it should be possible to select seeds for a planting site that have the best chance of success.

The key lies in the wide variety of habitats—desert to montane—in which many western plant species occur. In testing seed populations of rubber rabbitbrush and big sagebrush, Meyer found that germination patterns varied with site of origin of the seed. She has found similar variations in more than 20 additional species of semiarid ranges, including basin wildrye, fourwing saltbush, winterfat, and Lewis flax.

"The basic function of a germination pattern is to time germination so that it occurs under conditions of minimum risk to the seedling," she explains. "It helps ensure that germination won't take place in conditions that are immediately favorable, but may pose a risk for the seedling." For example, a period of dormancy will prevent some fall-ripening seeds from germinating before spring.

Controlled germination tests are a key part of the Shrub Sciences Laboratory's research program. Here bitterbrush seeds are examined for their response to cold treatment.

The germination pattern tends to be consistent for a plant species occurring in a narrow habitat range, because environmental conditions are likewise consistent among populations. Conversely, Meyer says, "It's hardly surprising that, for populations of a species growing in radically different habitats, different patterns exist to promote successful establishment of seedlings."

Rubber rabbitbrush, a prominent component of seeding mixes for winter game range restoration and mine reclamation, illustrates Meyer's findings. It occurs over a wide range of habitats, from hot desert to cool subalpine communities. An autumn-flowering species, it has a germination pattern characterized by temperature-dependent dormancy.

In the lab. . .

Meyer tested the germination response of seed collections from 72 rabbitbrush populations to temperature. At 30° C, she found that all rubber rabbitbrush seeds are nondormant, while at lower temperatures the degree of conditional dormancy varies with the origin of the seeds. At 3° C, seed collections from warm desert habitats required less than 2 weeks to achieve 90 percent relative germination, but seed collections from montane habitats showed delayed germination requiring up to 20 weeks. At an intermediate temperature (15° C) montane collections sometimes exhibited dormancy even though they were ultimately able to germinate at lower temperatures.

From these and other test results she concluded that the dormancy pattern shown by rabbitbrush seeds may function as a predictive mechanism to increase the chances that germination will take place at the earliest suitable opportunity.

"Rubber rabbitbrush seed collections from different habitats all possess the ability to germinate under midsummer temperature regimes, but this is irrelevant ecologically," Meyer says. "Germination behavior under autumn and winter temperature regimes is more important for autumn-produced seeds. Differences among the seed collections from different habitats are most pronounced at this temperature range."

In habitats where winters are relatively mild, and risk of seedling death from drought increases rapidly as spring progresses, seeds are dispersed in early winter, a good time for seedling establishment and growth. The seeds are nondormant and will probably germinate quickly as soon as winter moisture comes.

In contrast, seeds in montane habitats are dispersed in early autumn, when temperatures are still relatively mild, but with the prospect of a prolonged period of winter snowpack. Most of the seed pool will be conditionally dormant under these conditions. Once snow comes, seeds from montane populations are able to delay germination for extended periods at the near-freezing temperatures often found beneath snowpack. The seeds will germinate toward the end of the prolonged chill period or immediately after spring melt-off.

Seeds from warm desert habitats, she concluded, would germinate too rapidly for successful establishment in montane regions. Seedlings would be killed by snow and freezing temperatures. Conversely, seeds from montane habitats might delay germination so long that seedlings would risk death from drought, or seeds might fail to germinate at all.

Meyer found similar habitat-related differences in germination patterns of big sagebrush, another autumn-flowering species. Seeds of populations from cold winter sites have more conservative germination features than seeds from warm winter sites. These features function to postpone germination until late winter or spring, when snowpack should have melted. Populations from warm winter sites have seeds adapted for germination in early winter, soon after dispersal, so that seedlings may become established before soils dry out in the spring.

. . . And in the field

Meyer put her laboratory results to the test in germination experiments at field sites. Rubber rabbitbrush and big sagebrush seedlots collected from different vegetative types were seeded in small plots in three different vegetative types: Wyoming big sagebrush, pinyon-juniper, and mountain brush.

Results confirmed the expected differences in emergence and survival patterns within each vegetative type. Although weather events had an overriding effect for all seedlots, the probability of successful establishment at a particular site was increased by using seedlots collected at similar sites.

"A 1 percent return on seed is usually sufficient for establishment of successful stands using commonly recommended seeding rates," Meyer says. "We achieved seed returns of up to 10 percent by using site-matched seedlots, while use of poorly adapted seedlots resulted in much reduced or nonexistent stands."

Meyer notes that, of the many factors that affect probability of successful stand establishment—seed viability, below-normal precipitation, competition from weeds and other seeded species, planting techniques, etc.—seed origin is one that is under the land manager's control. She believes that taking the trouble to obtain a site-matched seedlot for seeding these species will pay off.

"Taking the trouble" is no casual expression. Many native seed companies do not specify the origin of their seedlots. Buyers must inquire, and they may receive an equivocal answer because companies are reluctant to divulge the location of valuable seed collection sites. An alternative for land managers is to contract the selection of seeds from sites of their choice, thus ensuring that seeds of a suitable ecotype are collected for each artificial seeding project.

Meyer recovers sagebrush seeds from a snow stratification study plot. Wire mesh cones protect the seeds from animal predation.

It is becoming easier for managers to obtain seeds of some native species because of other work being carried out at the Shrub Sciences Laboratory. Scientists are developing "released cultivars," strains of some shrubs and other native plants that can be cultivated for seed production. Not only is seed more cheaply and easily obtained from field plantings, but the ecotype is known. And seed orchards can be managed and fertilized to enhance seed production. Because released cultivars have been selected and developed for different attributes—palatability, rapid growth rate, ease of establishment, etc.—land managers can select the most appropriate for a specific seeding project.

New challenges

The landscape described by Robert Reynolds almost 80 years ago is becoming rare today. Not only is grazing managed, but efforts to restore overgrazed rangelands have been widely successful, thanks in part to the pioneering research conducted at the Shrub Sciences Laboratory.

New challenges are confronting land managers at the end of the century. Cheatgrass is invading large range areas as wildfires burn out shrubs and other forage plants. Fires sweep with increasing frequency through areas invaded by this flashy fuel. Shrubs are dying out in the Intermountain area from causes that are not understood, and alien weeds prevent their natural reestablishment from seed. Huge mining projects pose new challenges in rehabilitating disturbed lands. Wildlife habitat is being lost to urban development.

Meyer and her colleagues at the Shrub Sciences Laboratory are working closely with managers to identify problems and help them apply new solutions. If you would like information about germination patterns and their implications for artificial seeding, contact Susan Meyer at the Shrub Sciences Laboratory, 735 North 500 East, Provo, Utah 84606, (801) 377-5717, FTS 586-5686.

Emergence and performance of sagebrush populations are tested in research plots.

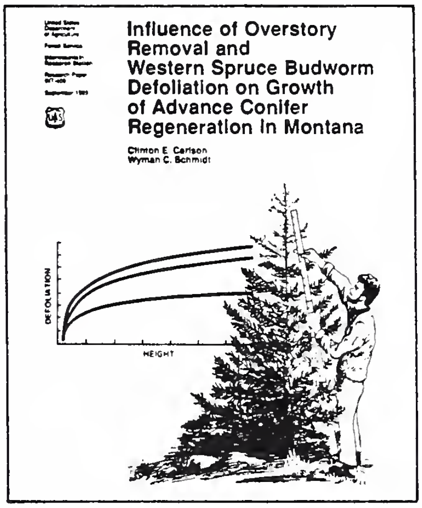
New from research

What to expect from culturing advance regeneration

With the current interest in uneven-aged management of forest stands, a new study of the growth of advance regeneration will aid managers in evaluating its merits for timber production.

The study suggests that culturing advance regeneration on productive sites in the Northern Rockies may not be wise if the primary objective is to produce timber. Not only is growth response of advance regeneration found to be mediocre, but the resulting uneven-aged stands of shade-tolerant conifers have increased susceptibility to western spruce budworm infestation. Repeated defoliation during budworm epidemics, along with mediocre height growth response, can result in yield reductions of more than 40 percent at rotation compared to stands composed of seral species.

Suggestions are included for enhancing timber values in those situations where, considering all important resource values, management of advance regeneration is considered the best option.



Influence of Overstory Removal and Western Spruce Budworm Defoliation on Growth of Advance Conifer Regeneration in Montana

Clinton E. Carlson
Wyman C. Schmidt

Request *Influence of Overstory Removal and Western Spruce Budworm Defoliation on Growth of Advance Conifer Regeneration in Montana*, Research Paper INT-409, from the Intermountain Research Station.

Mule deer diet on forage improvement projects reported

In the pinyon-juniper habitats that form a large portion of the winter-spring mule deer range in the Great Basin, forage values have declined because of overgrazing, fire suppression, and dominance by overstory species. To increase forage production, managers have treated large areas, often by chaining and seeding. A new report characterizes the forage used by mule deer on a chained and seeded winter-spring range.

Browse plants, particularly big sagebrush, were the largest component of the mule deer diet. Alfalfa introduced in the seeding treatment was an important forage in early spring. Grasses formed a relatively high proportion of the deer's diet in comparison with studies of untreated sites, perhaps reflecting greater availability on treated sites. Implications for seeding and management of treated sites are included in the report.

Request *Mule Deer Diets on a Chained and Seeded Central Utah Pinyon-Juniper Range*, Research Paper INT-410, from the Intermountain Research Station.

Height-age and site index curves for Pacific silver fir

Forest managers increasingly examine upper slope forests in the Cascade Range in the Pacific Northwest. To help managers accurately assess stand productivity in these forests, the authors of a recent research paper provide height-age and site index curves for Pacific silver fir—a major species in the upper slope forests.

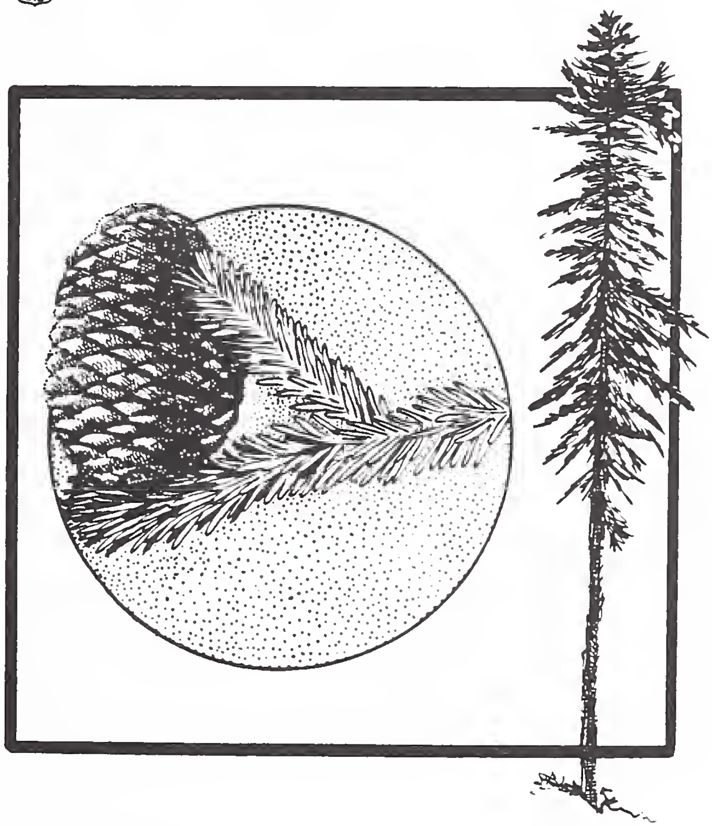
The paper describes how the curves were developed based on felled and sectioned trees. Height-age curves are based on free-growing trees between 100 and 300 years old. A general Guideline is presented for identifying nonfree-growing dominant trees. A multiple regression equation was developed to express site index (height at age 100) as a function of total tree height and age at breast height. Equations were developed for estimating how many years free-growing trees need to reach breast height for the range of site index curves. Conversion equations are also provided to estimate height at age 50 for curves representing index heights at age 100.

For a copy, request Research Paper PNW-418, *Height-age and Site Index Curves for Pacific Silver Fir in the Pacific Northwest*.

United States Department of Agriculture
Forest Service
Pacific Northwest Research Station
Research Paper PNW-RP-418
September 1989

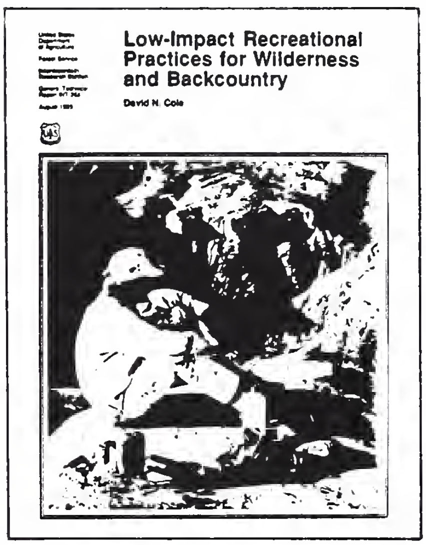
Height-Age and Site Index Curves for Pacific Silver Fir in the Pacific Northwest

Gerald E. Hoyer and Francis R. Herman



New source book can help reduce recreation impacts

Most people think of wilderness and backcountry areas as remote and secluded, but recreation managers know better. They often find the popularity of these areas evidenced by eroded trails, trampled vegetation, piles of litter, and a profusion of fire rings. Reservation systems and other restrictions have been instituted in many areas to minimize and control impacts.



Restrictions that remove the free and spontaneous feeling of wilderness recreation can be avoided where visitors voluntarily use low-impact practices. A new source book, *Low-Impact Recreational Practices for Wilderness and Backcountry*, helps managers educate backcountry users on ways to "leave no trace."

It describes common problems caused by recreational use and summarizes low-impact practices that are effective in reducing these problems. The rational for each practice is explained and costs to visitors are described. The source book also provides guidance on tailoring low-impact recommendations to different environments and user groups.

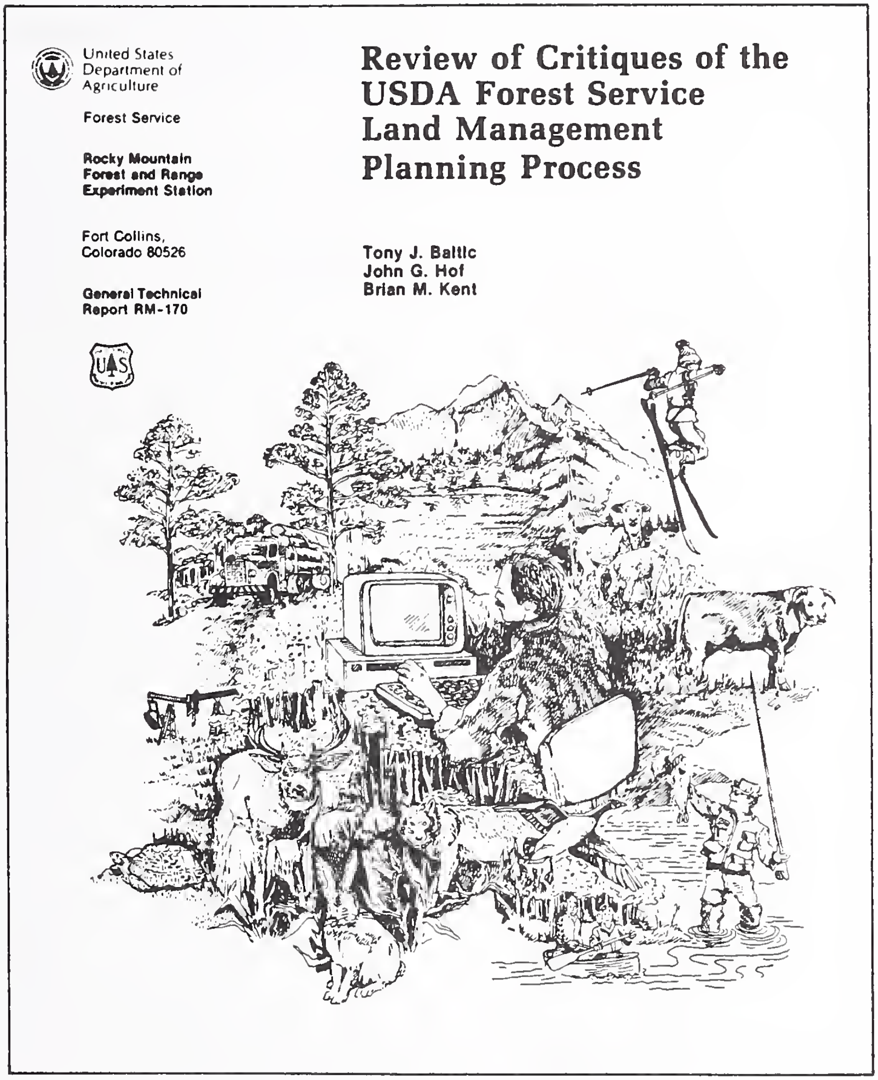
Request General Technical Report INT-265 from the Intermountain Research Station.

More water from southwestern forests

Snowfall in high-elevation forests is an important source of water for much of the arid Southwest. However, less than 10 percent of the yearly precipitation is recovered for human use. Researchers believe this percentage can be increased through forest management activities. To test this theory, scientists at the Rocky Mountain Station are conducting studies and field work in Arizona and New Mexico. An important part of the research involves the use of computer programs to predict snowpack accumulation, redistribution, melting, and resulting surface runoff. Aerial photography and satellite imagery is also used to forecast snowmelt and runoff.

Results show snowpacks can be increased by reducing the density of forests, or by removing forest overstories.

For a copy of the reprint titled *Water Yield from Forest Snowpack Management: Research Findings in Arizona and New Mexico*, write the Rocky Mountain Station.



Help for land management planners found in recent report

The question of how to manage national forests has long been debated. The Forest Service has completed an initial round of planning and is about to embark on its next one. A recent review of past land management planning process critiques has been compiled in a new report to aid future planners.

The authors evaluate critiques based on how effectively they adhere to the National Forest Management Act of 1976 (NFMA). Each critique is judged for quality and analyzation of data, and objectiveness. Since a large number of critiques exist, only a sample is reviewed.

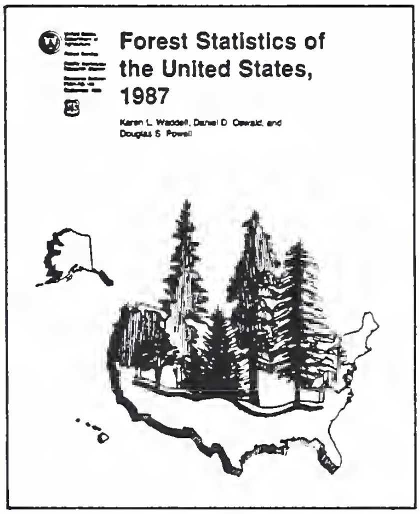
Rather than looking for a consensus among critiques, the authors choose to highlight diverse points of view. They suggest the most effective critiques not only recognize diversities, but show how they can work within the political aspects of management.

For a copy of *Review of Critiques of the USDA Forest Service Land Management Planning Process*, request General Technical Report RM-170, available from the Rocky Mountain Station.

U.S. forest statistics presented

Every 10 years, forest and range land resources are assessed as directed by the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974. Many volumes of information have now been compiled for the 1989 RPA Assessment. The Pacific Northwest Research Station has issued a resource bulletin that extracts information from a RPA volume that focuses on the current timber situation in the United States.

The bulletin presents information collected and summarized from periodic resource surveys in each State and Forest Service Region. Tables include information on area, volume, removals, and timber product outputs. The dates of surveys differ because they were conducted periodically in different years; however, for states and regions, data on growth, mortality, and harvest were updated to the common year of 1986 and data on inventory volume and timberland area were updated to 1987. Historical data is also presented for 1952, 1962, 1970, and 1977.



For a copy request Resource Bulletin PNW-168, *Forest Statistics of the United States, 1987.*

Dwarf mistletoe vs lodgepole pine

Lodgepole pine is the most widely distributed conifer in western North America, and one-fourth of its annual harvest comes from the Rocky Mountain states. Many pests plague this widespread pine. but two are especially destructive: dwarf mistletoe and mountain pine beetle. Dwarf mistletoe is the most common and damaging disease agent.

A recent report written by forest pathologists at the Rocky Mountain Station and Rocky Mountain Region, and published by the Rocky Mountain Station, addresses this common disease. The report synthesizes information from over 1,000 publications on dwarf mistletoe. A complete analysis of biology, ecology and damage is given, along with 40 colored illustrations. The report concludes with recommendations for minimizing dwarf mistletoe damage in lodgepole pine forests managed for commercial timber production or for recreation.

For a copy of *Biology and Management of Dwarf Mistletoe in Lodgepole Pine in the Rocky Mountains*, write the Rocky Mountain Station and request General Technical Report RM-169.

Computer model simulates fire effects

The long-term effects on forest composition and structure of different fire management alternatives, such as complete suppression of all fires and prescribed fires of varying intervals and prescriptions, are often difficult to quantify. A new computer model, FIRESUM, enables managers to simulate the effects of successive fires (a fire regime) on tree composition, stand structure, and fuel loading in forests of the Northern Rockies.

Among the model's uses are evaluating cumulative effects of different prescribed burning schedules on tree composition and structure, assessing insect- and disease-caused tree mortality related to fire frequency, predicting stand productivity at varying fire frequencies, and evaluating wildlife habitat potential under different fire regimes.

The model simulates tree establishment, growth, and mortality, along with live and dead fuel accumulation, fire behavior, and fuel reduction on a 400-square meter plot. Influences on tree establishment and growth included in the model are growing season warmth, water stress, light tolerance, and site quality.

General Technical Report INT-266, *FIRESUM—An Ecological Process Model for Fire Succession in Western Conifer Forests*, describes the model, and provides examples of model output, a sensitivity analysis, and validation results. Request it from the Intermountain Research Station.

United States Department of Agriculture

Forest Service

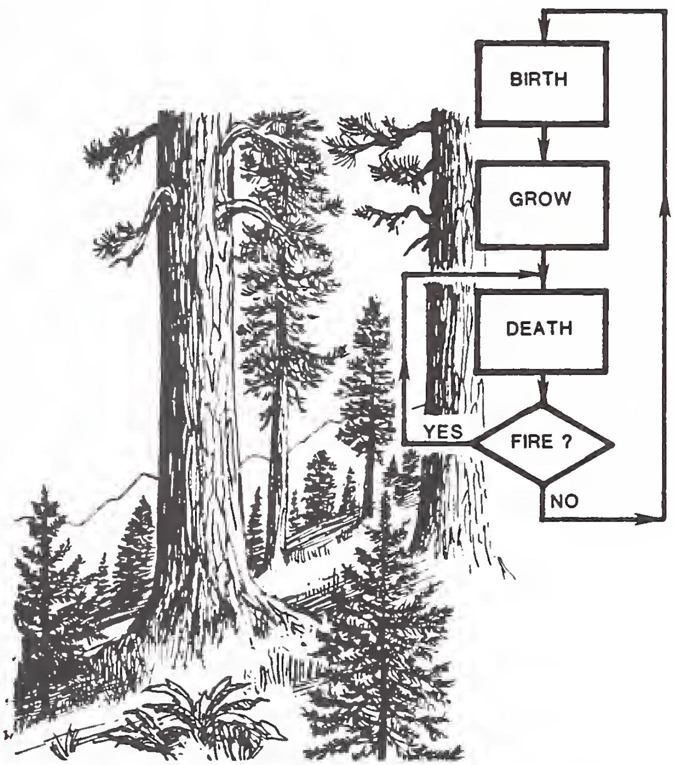
Intermountain Research Station

General Technical Report INT-266

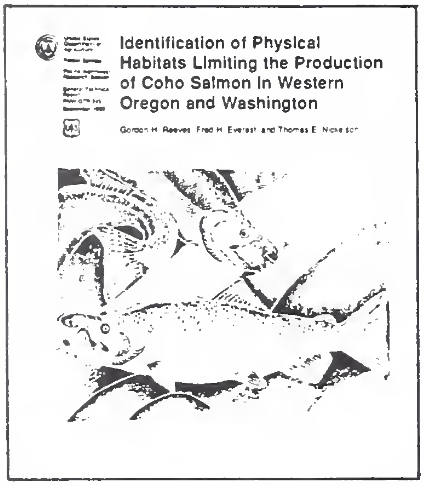
September 1989

FIRESUM—An Ecological Process Model for Fire Succession in Western Conifer Forests

Robert E. Keane
Stephen F. Arno
James K. Brown



Habitat key for managing coho salmon



Fisheries managers have a new tool for enhancing habitat for coho salmon in western Oregon and Washington. A publication issued by the Pacific Northwest Research Station provides the first formal procedure (in the format of a key) for identifying physical habitats limiting production of the salmon.

The key is most accurate for streams up to large fourth-order and small fifth-order streams. The key has several requirements: quality inventory data, evaluation by experienced managers, and two surveys of the habitat in the entire portion of the basin used by the coho salmon. Data needed includes amount of summer and winter rearing area and spawning gravel, summer and winter water temperature, stream gradient and other measurements. Although total number of coho salmon during low-flow survey and pattern of habitat use are not required, this information improves the outcome of the key, as does fish population estimates.

For a copy, request General Technical Report PNW-245, *Identification of Physical Habitats Limiting the Production of Coho Salmon in Western Oregon and Washington*.

Guide for users of PC version of TRIM

The timber resource inventory model (TRIM) was designed to help predict timber inventories in analyses of regional timber policy. The large bookkeeping system requires parameters for determining growth, yield, and harvest actions. With an "open framework" design, the model can be used nationwide.

Originally designed for a mainframe computer, TRIM has been updated for personal computers (PC-TRIM); the latter receives the most use. Until recently, PC users relied on a user guide developed for the mainframe. Now, a publication is available that supplements the mainframe-directed publication. Information in this new publication helps users manage program input and output in the DOS environment and avoid common mistakes that can lead to program-generated errors. Differences between PC-TRIM and mainframe TRIM are also explained.

For a copy, request Research Note PNW-491, *An Introduction to PC-TRIM*.

To order any of the publications listed in this issue of *Forestry Research West*, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

Please send the following Pacific Northwest Station publications:

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1. *Identification of Physical Habitats Limiting the Production of Coho Salmon in Western Oregon and Washington*, General Technical Report PNW-245.
2. *An Introduction to PC-TRIM*, Research Note PNW-491.
3. *Height-age and Site Index Curves for Pacific Silver Fir in the Pacific Northwest*, Research Paper PNW-418.
4. *Forest Statistics of the United States, 1987*, Resource Bulletin PNW-168.
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1. *Wildlife Associated with Scoria Outcrops: Implications for Reclamation of Surface-mined Lands*, Research Paper RM-285.
2. *Water Yield from Forest Snowpack Management: Research Findings in Arizona and New Mexico*, a reprint.
3. *Review of Critiques of the USDA Forest Service Land Management Planning Process*, General Technical Report RM-170.
4. *Biology and Management of Dwarf Mistletoe in Lodgepole Pine in the Rocky Mountains*, General Technical Report RM-169.
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2. *Influence of Overstory Removal and Western Spruce Budworm Defoliation on Growth of Advance Conifer Regeneration in Montana*, Research Paper INT-409.
3. *Mule Deer Diets on a Chained and Seeded Central Utah Pinyon-Juniper Range*, Research Paper INT-410.
4. *Low Impact Recreational Practices for Wilderness and Backcountry*, General Technical Report INT-265.
5. *Effects of Prescribed Fire on Biomass and Plant Succession in Western Aspen*, Research Paper INT-412.
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Rejuvenating aspen with prescribed fire

The widespread quaking aspen forests in western North America are highly valued for wildlife habitat, livestock forage, and water yield. Today the existence of seral aspen is threatened by lack of stand-perpetuating fires. Prescribed fire offers an economically and environmentally acceptable way to rejuvenate these forests.

To use prescribed fire effectively, forest managers must know how aspen and understory vegetation will respond to fire of known characteristics. A new publication from the Intermountain Research Station describes the varied response of aspen suckers, shrubs, and herbaceous vegetation to different levels of fire severity. Some guidelines for applying prescribed fire are included.

Request *Effects of Prescribed Fire on Biomass and Plant Succession in Western Aspen*, Research Paper INT-412.

United States
Department
of Agriculture

Forest Service

Intermountain
Research Station

Research Paper
INT-412

October 1989

Effects of Prescribed Fire on Biomass and Plant Succession in Western Aspen

James K. Brown
Norbert V. DeByle

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